CLAIMS

1. A phase-shifting cell (4) of a reconfigurable reflectarray (3) for an antenna operating in the microwave range, said reflectarray comprising a plurality of identical elementary phase-shifting cells, each of said cells having two plane parallel faces separated by a thickness representing about one quarter of the wavelength of the operating frequency, said first face having a star-configured array consisting of an even number of electrically conducting strands (7) that are all identical and placed uniformly around a central disk (8), which is also conducting, it being possible for each strand to be electrically connected to the central disk via a switching device dependent on a control voltage, each pair of diametrically opposed strands thus constituting, when the two switching devices connecting them to the central disk are activated, a resonant dipole in the range of operating frequencies of the antenna, the second face consisting of a ground plane, said cell being characterized in that each switching device consists of a micro-electromechanical system comprising a flexible membrane (11) supported by at least two pillars (14) that are placed between said membrane and the first face of the cell, said membrane thus being placed above the end (71) of each strand facing the central disk and that peripheral part (81) of said disk which is placed facing this end, said membrane, when the control voltage is applied, being deformed by the resulting electrostatic force sufficiently to ensure electrical connection between the end of the strand and the corresponding peripheral part of the central disk, said switching device being of the capacitor type and the electrical connection corresponds to a large increase in its capacitance.

2. The phase-shifting cell as claimed in claim 1, characterized in that the ratio of the value of the capacitance of the capacitor in the absence of a control voltage to the value of the capacitance when the control voltage is applied is of the order of 100.

3. The phase-shifting cell as claimed in claim 1, characterized in that the plates of the capacitor consist, on the one hand, of the flexible membrane (11) and, on the other hand, of the end of the strand (71) and of

the peripheral part (81) of the corresponding disk that are placed beneath this membrane, electrical isolation being provided by a layer of dielectric material covering the strands and the disk.

4. The phase-shifting cell as claimed in claim 3, characterized in that the dielectric material used is preferably silica nitride (Si_3N_4).

5. The phase-shifting cell as claimed in claim 1, characterized in that the geometrical and mechanical parameters of the membrane are designed in such a way that the control voltage to be applied, in order to ensure switching, is large compared with the possible parasitic voltages.

6. The phase-shifting cell as claimed in claim 5, characterized in that this control voltage is typically thirty volts.

7. The phase-shifting cell as claimed in claim 5, characterized in that the membrane has roughly the shape of a rectangular parallelepiped of small thickness, the width of the rectangle typically being one hundred microns, its length three hundred microns and its thickness seven hundred nanometers.

8. The phase-shifting cell as claimed in claim 5, characterized in that the membrane and the pillars that support it consist mainly of gold or aluminum layers or layers of tungsten titanium alloys.

9. The phase-shifting cell as claimed in claim 2, characterized in that, in the absence of a control voltage, the space between the membrane and those parts of the central disk and of the strand that are placed beneath it is about three microns.

10. The phase-shifting cell as claimed in claim 1, characterized in that the end (71) of the strand and the facing part (81) of the central disk that are placed beneath the membrane make up a comb of interdigitated fingers.

11. The phase-shifting cell as claimed in claim 10, characterized in that the total number of fingers is five.

12. The phase-shifting cell as claimed in claim 1, characterized in that the voltages for controlling the switching devices pass via the strands by means of internal resistive lines (151) and in that the flexible membranes are all connected to the electrical ground, also by means of other internal resistive lines (154, 155).

13. The phase-shifting cell as claimed in claim 12, characterized in that the material used to produce the various electrical connections is preferably gold.

14. The phase-shifting cell as claimed in claim 12, characterized in that the value of the impedance of the resistive lines at the operating frequency is high enough to isolate all the strands, the central disk and the switching devices from the outside.

15. The phase-shifter device as claimed in one of claims 1 to 14, characterized in that the cell is of hexagonal shape and comprises twelve strands (7).

16. The phase-shifting cell as claimed in one of claims 1 to 15, characterized in that each strand has a flared shape, the flare angle being about 20 degrees.

17. The cell as claimed in one of claims 1 to 16, characterized in that the electronic system of said cell, formed by the strands (7), the central disk (8), the switching devices and the various resistive lines (151, 154, 155) supplying the control voltages and the electrical ground, is implanted on a central microwave-transparent substrate (61), this substrate being especially made of silicon or quartz or glass, especially glass with the Pyrex brand name.

18. The cell as claimed in one of claims 1 to 17, characterized in that said substrate (61) takes the form of a right cylinder with plane parallel faces, of circular or hexagonal base centered on the central disk of the cell.

19. The cell as claimed in one of claims 1 to 18, characterized in that the upper part of the substrate (61), which comprises the central disk and the various switching devices, is protected by a protective cover (19) transparent to the operating microwave electromagnetic waves.

20. The cell as claimed in one of claims 1 to 19, characterized in that the substrate (62) common to the reflectarray system has two plane parallel faces, the upper face bearing the various central substrates corresponding to each cell, and the opposite face having a ground plane (10).

21. The cell as claimed in claim 20, characterized in that this substrate (62) is based in particular on PTFE and glass fibers, this substrate possibly being the material having the brand name METCLAD, sold by Neltec.

22. The cell as claimed in one of claims 1 to 21, characterized in that each cell is connected by a paving of circular connection studs (171) that are produced in the common substrate and arranged in rows forming a hexagon, each hexagon being centered on the central disk of each cell, each of the internal resistive lines of a cell that emanate from the strands or from the membranes being connected to these studs (171) via other external resistive connections (153) implanted on the common substrate, the internal resistive lines implanted on the central substrates of each cell being connected to the external resistive lines implanted on the substrate of the reflectarray by means of wire-bonding connection wires (152).

23. The cell as claimed in claim 22, characterized in that each hexagon of connection studs has a number of studs equal to at least twice the total number of strands of each cell, increased by two.

24. The cell as claimed in claims 22 and 23, characterized in that the rows of connection holes are common to two adjacent cells.

25. The cell as claimed in one of claims 1 to 24, characterized in that each cell is surmounted by a set of six metal separating walls (18) arranged in a hexagon above the connection holes, said walls being connected together and grounded via metal pins (172) located, on one side, in the walls and, on the other side, in certain connection holes reserved for this purpose. The set of walls of the cells forms a honeycomb grid lying above the reflectarray.

26. The cell as claimed in one of claims 1 to 25, characterized in that the electrical isolation of each cell with respect to the adjacent cells is achieved, on the one hand, by the paving with connection holes and, on the other hand, by the metal walls placed above each cell.

27. The cell as claimed in one of claims 1 to 26, characterized in that the entire reflectarray is covered with a multilayer dielectric treatment.

28. A process for producing the cell as claimed in claims 1 to 27, characterized in that the step for producing the switches comprises the following substeps:

- deposition of a layer of dielectric material at the location of the switching region;
- deposition of a layer of photoresist covering at least the location of the membrane and of its support pillars;
- removal of said resist at the location of each pillar;
- creation of the pillars (14) and of the membrane (11) by deposition of at least one metal layer at the locations of said pillars and of the membrane; and
- removal of the resist at least beneath the membrane so that the membrane (11) on these pillars (14) is left free.

29. The process for producing the cell as claimed in claims 17 to 27, characterized in that it comprises the following steps:

- production of the printed circuit substrate (62), common to the cells (4) by:
  - deposition of the ground plane (10) and
  - production of the electrical connection studs (171), plated-through holes and metallized pads;
- production of the central microelectronic substrates of the cells (61);
- deposition of the various electronic devices on these substrates by:
  - production of the strands (7), the central disk (8) and the resistive lines (7, 151, 154, 155) and
  - production of the switching devices;
- protection of the switching devices by installing covers (19);
- installation of the central substrates (61) on the common substrate (61);
- production of the resistive lines (153) and their electrical connection to the connection studs (171); and
- placing of the isolating grids on the rows of connection studs and installation of the mechanical supports (172).